SAFEX INTERNATIONAL

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CONTENTS

SAFEX CONGRESS XX

SALZBURG

23 till 28 April 2023

From the Desk of the SG

It is six months since the last SAFEX Newsletter and the pandemic is still with us, but the human race is very resilient. Despite devastating conditions over the last two years, people have now started to realize that Covid is here to stay, and we are adapting to this new life. Higher awareness of hygiene, masks vaccinations and a change in overall behavior have all made it possible to return to a new normal.

The same evolurion happens in our industry industry .We progressed over several centuries from black powder to nitroglycerine to watergels and currently emulsions- from safety fuse to shock tube and electric detonators to electronics. All these technologies came with massive challenges, but the industry adapted and moved forward to make these products the best and safest in each time era. New technologies are being developed and the current generation of managers will face new challenges. With any new innovations there are risks, in our industry it is SH&E around the manufacture and application of products. Although all industry members deal with these using their own systems and expertise, SAFEX International was created by a few visionary CEO's 68 years ago to assist our members through:

- Sharing of knowledge -Incident Reports, Congresses, and Webinars.
- Assistance where there is a lack of internal expertise – Expert Panel, other experts currently in the industry, Good Practice Guides.
- Training- Webinars, eLearning Portal, Safex Website, Good Practice Guides.
- Communication- Associate Members, Related Conferences, UN Participation

To make a success of all the SAFEX initiatives and ensure an always safer and more complaint industry we need your help and commitment to keep the path of the evolution of our industry safe to draw the best customers, investors and employees. This will drive us to become the top tier industry globally.

Following on from this I can report that the SAFEX eLearning modules are now available in:

- English
- French
- Portuguese
- Russian and
- Spanish

at **http://www.safex-training.org**

We also have an Emulsion Safety Module on the website which is now complemented by the Sierra Incident Training Case Study- both these are available on the Learning drop down menu on the site. : **https://www.safex-international.org .**

An article in this Newsletter introduces the Sierra Package to members. Plans are in place to develop a similar training package on ESD.

A very successful Webinar (the third) on PETN Safety in Manufacture, Storage and Use was held on 27 April attended by over a 180 people from across the globe. The Webinar was organized by the PETN Workgroup and hosted by Austin, and we are grateful for their support and commitment. Two more will be organized Webinars during the course of 2022.

Organization of the SAFEX 2022 Congress is well in hand and regular communications will be released to members during the coming months. The call for papers was issued and the response thus far was good. Please note the dates of 23 till 28 April 2023, Salzburg, Austria in your dairies.

CONGRESS 2023 PROGRAMME

DATE	ACTIVITY	CONCURRENT ACTIVITY
Sunday, 23 April	Registration - Training	
Monday, 24 April	Registration - Training Training Session	
Tuesday, 25 April	Training Session Registration – Workgroups	
Wednesday,26 April	Registration - Workgroups Workgroup Sessions Registration - Congress Welcome Reception	
Thursday,27 April	Registration - Congress Plenary Sessions – Open Day Board Meeting	Spouses' Programme
Friday, 28 April	Plenary Sessions – Closed Day General Assembly of Members Gala Dinner	Spouses' Programme
Saturday, 29 April	Congress Excursion	

Salzburg Conference Centre

We start this Newsletter with a message from our Chairman, John Rathbun, in which he expresses his commitment to SAFEX ,safety and concern about recent incidents.

Message from SAFEX Chairman – John Rathbun, CEO, Austin Powder

Dear Safex Members,

Our industry has recently seen too many incidents. We've been starkly reminded that our business is unforgiving towards oversights, operational mistakes, haphazard handling or even the random, potentially tragic hazards found on the road. Every explosion has something to teach us and, in many cases, re-teach us and remind us that all our products require respect, specific knowledge and regular training for those folks closest to them. It is the mission of Safex to share this gathered knowledge to improve the industry we work in and keep each other safe.

The recent spate of incidents covers a whole host of products. We've seen ANFO detonate due to a fire caused by a traffic accident. We've seen detonators being unloaded from the factory go to detonation with fatal results. We've seen a dynamite plant just shoot its mix house, an emulsion plant disappears and for us at Austin Powder, we had our acetone distillation column connected to our HMX plant detonate. We don't understand yet why this happened and fortunately for us, our employees suffered injuries that while serious they were not grave.

However, with the help of experts from the Safex community and our own investigation team, Austin has already started to investigate this event and our commitment will be to share our learnings with the Safex community. While it is understood that there are few HMX plants around the world, there are certainly likely to be learnings that will help others with perhaps other processes that might benefit from these yet-to-be-discovered facts or assertions as to why we failed at that moment and had a detonation.

HMX Incident

This isn't the first time we have used the Safex community to help us through an incident and we are always leaning forward to help others if they request it in their time of need. We've done that recently for a fellow member who needed product delivered to their customers after an event. We recognize that our industry's posture has always been this way and Safex is at the core of this spirit. I would also be remiss if I didn't share that after our HMX event, we too received calls of support from many levels of management within competing companies offering their support of expertise or supply of product to help us continue to support our customers. I am very thankful that our industry has these reflexes when we need them the most.

Thank you all for your contributions to making Safex more relevant to our workforces and leaders every year. While COVID has caused us to miss a complete congress cycle, after three practice runs, we are all on-target for our next one, next year in Salzburg, Austria. I look forward to seeing many of my old friends there and to hopefully meet some new ones. We already have lots to share and learn from.

The Sierra Chemicals e-Module

By

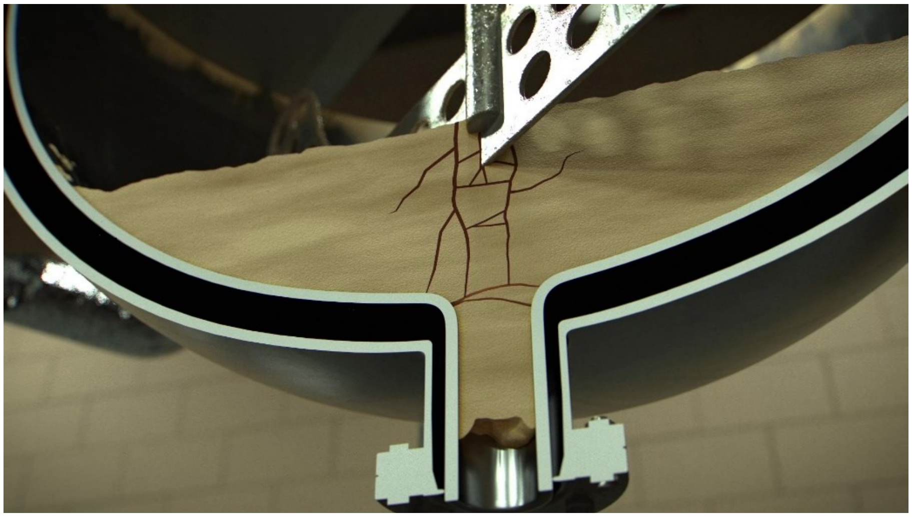
Andy Begg and Martin Held

The SAFEX website has a new module loaded for our members to use as an educational and training aid.
The module is based on the formal investigation into the explosion in the Sierra Chemicals cast booster plant located in Mustang, Nevada in 1998 by The Chemical Safety and Hazard Investigation Board (CSB) in which 4 workers were killed and a further 6 injured.

(Slide from the animation sequence in the module)

The CSB is an independent US federal agency with the mission of ensuring the safety of workers and the public by preventing or minimizing the effects of chemical incidents at industrial facilities and in transport. The CSB is a scientific investigatory organization; it is not an enforcement or regulatory body.

The report contains many good investigational practices and identifies and prioritises multiple potential initiation scenarios. It also identifies a range of contributory factors from failures in local management to lack of regulatory oversight.

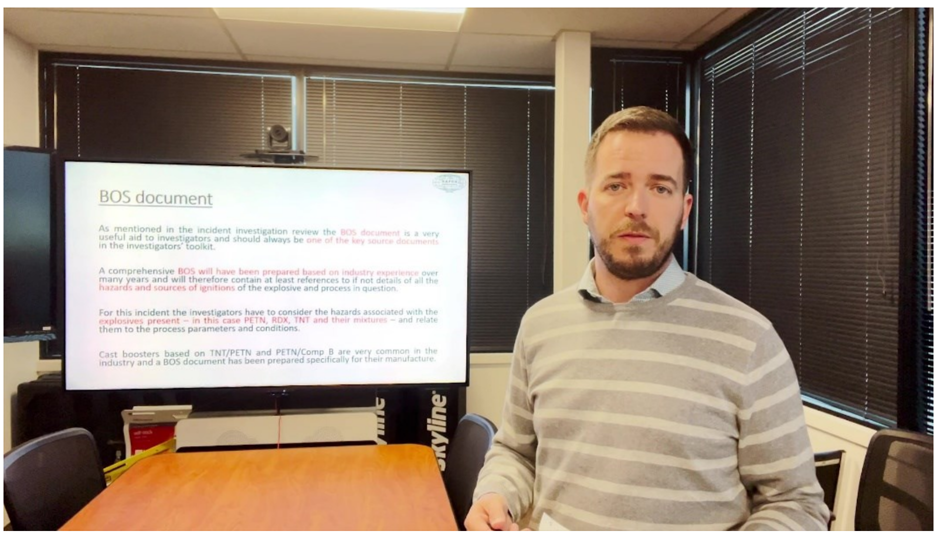


(Slide from the animation sequence in the module)

As there is a considerable amount of information available on the incident and the investigation, we have chosen to use the incident in this e-module to emphasise the value of effective auditing and implementation of Basis of Safety (BOS) systems in preventing and investigating incidents.

(Slide from the animation sequence in the module)

The detailed review of the investigation process and findings in the preparation of this module has indicated that by following a structured process safety approach based only on Process Safety Management (PSM) requirements the investigation team did not identify all potential initiation scenarios that would be considered by including a BOS approach. We decided therefore to include a training exercise in the module to ensure incident investigations follow a more rigorous process.



Joao Roorda Presenting the Exercise Session

In an explosion investigation it is very important that every potential source of ignition is considered by the team. Many potential sources may be discounted very quickly as "not possible" in the circumstances while others will be added to the list of "possible" for further analysis – the important point is to at least consider all possible sources at the start of the investigation. A BOS document helps immensely in this as the list of potential sources can be used as a checklist by the investigation team.

The module is best used in a training workshop situation with a local facilitator as it includes an exercise suitable for group working

We are very grateful to Joao Roorda for volunteering to be the presenter in the exercise section. Also, thanks to Austin Powder and Enaex for providing visual illustrations.

SHE AUDITING

by

MD TRAUT OF MD TRAUT CONSULTING

1.WHY AUDIT?

SHE auditing underpins the monitoring and verification process, with the overall objective of providing assurance that all aspects of SHE are being managed in accordance with the pertinent requirements.

While audits should be focused on critical systems one must not lose sight of the relevant supporting systems.

Where deviations are found the correction of these must stimulate and drive ongoing improvement and correction of the situation and ultimately lead to a preventative strategy and enhanced and continuous performance.

It should be borne in mind that in some types of auditing the examination of the audit findings are clear cut and essentially require answers to yes/no questions (e.g., as for much of financial auditing). however, for SHE auditing the issues are not "black and white" and audits are really "**assessments' of the extent of conformance, with gradations on a scale from zero to full.**

2.WHO CARRIES OUT THE AUDIT?

Audits should be conducted internally as well as externally.
An **internal audit (also referred to as a first-party audit)** is performed **within** an organization to measure its strengths and weaknesses against its own procedures or methods and/or against external standards adopted by (voluntary) or imposed on (mandatory) the organization. A first-party audit should preferably be an internal audit conducted by auditors who are employed by the organization being audited **but who have no vested interest in the audit results of the area being audited.**
An independent audit is performed by an audit organization independent of the customer-supplier relationship and should be free of any conflict of interest. Independence of the audit organization is a key component of a third-party audit.
Third-party audits may result in certification, registration, recognition, an award, license approval, a citation, a fine, or a penalty issued by the third-party organization or an interested party.

2.TYPES OF AUDITS

There are many types of audits that can and should be carried out. Below, there given a brief description of some of these that are often carried out.

- **A Process audit**

  This type of audit verifies that processes are working within established limits. It evaluates an operation or method against predetermined instructions or standards to measure conformance to these standards and the effectiveness of the instructions. A process audit may:
  - ♦ Check conformance to defined requirements such as time, accuracy, temperature, pressure, composition, responsiveness, amperage, and component mixture.
  - ♦ Examine the resources (equipment, materials, people) applied to transform the inputs into outputs, the environment, the methods (procedures, instructions) followed, and the measures collected to determine process performance.
  - ♦ Check the adequacy and effectiveness of the process controls established by procedures, work instructions, flowcharts, training and process specifications.

- **A Product audit:**

  This type of audit is an examination of a particular product or service, such as hardware and software or processed material, to evaluate whether they conform to requirements (i.e., specifications, performance standards and or customer requirements).

- **A Management Systems' audit:**

  This type of audit can be described as a documented activity performed to verify, by examination and evaluation of objective evidence, that applicable elements of the systems are appropriate and effective and have been developed, documented, and implemented in accordance and in conjunction with specified requirements. These audits in include but are not limited to:

  - A **Quality Management System** audit evaluates an existing quality management program to determine its conformance to company policies, contract commitments and regulatory requirements.
  - Similarly, an **Environmental System's** audit examines an environmental management system.
  - A **Basis of Safety System (BoS)** audit for all manufacturing and operational activities, evaluates the practice that for all explosives operations, the **BOS** is based on: **THE LIMITING THE EXPOSURE TO THE MINIMUM QUANTITY OF EXPLOSIVES TO THE LEAST NUMBER OF PERSONS, FOR THE MINIMUM PERIOD, BY EMPLOYING SAFE AND EFFICIENT OPERATIONS.**
  - A **change management system** audit evaluates the adherence to the standards defining the requirements for the operations and business units to identify and manage the potential safety, health, environment, quality and physical security risks, associated with changes to be made to equipment/plant/raw materials/procedures and the conducting of trials, the setting of up of process control systems, effecting temporary repairs or changing the organisational structures.
  - A **Hazard study** audit evaluates the compliance to the standards defining the requirements in all the areas which have been designated to be subjected to Hazard studies. It should also confirm that, where previous audits had identified problem areas, that these have been appropriately addressed.
  - Other audits of note are **:**
    - **RISK ASSESSMENTS** (these frequently accompany a Hazard study audit
    - **PERMIT TO WORK**
    - **ACCIDENT/INCIDENT INVESTIGATIONS**
    - **DOCUMENTATION**
    - **ACCIDENT/INCIDENT INVESTIGATIONS**
    - **SHE DOCUMENTATION**

4.WHEN TO CONDUCT AN AUDIT

Audits should be regular, scheduled and with a well-defined improvement goal.

The audit may be a one-time verification/examination of a required practice/action, limited in scope to a specific issue or a scheduled action with a systematic approach to address a number of key practices and procedures to test and assess them against appropriate standards, which could include:

- Statutory Regulations, National Standards and Codes of Practice, Industry Standards and Codes, Company Standards and Codes and other appropriate recognised good practices.
- An organised response to new information eg. As a result of a formal change or
- Acting upon a perceived problem.

5.AUDIT COMPONENTS

Audit components should cover the following:

- **Inputs to meet defined outcomes**

A complete audit programme should always include the two **KEY** components namely Monitoring and Verification.

These are combined with suitable corrective actions to ensure improvement. I.e., The audit brings together "what is actually being done" with "what should be done"

The amount of time dedicated/allocated to the persons conducting the audit may change over time. This would normally be in response to the condition of the audited entity and the degree to which previous audit findings have been closed out.

- **Auditors' skills**

Auditors need to have, through training, acquired the necessary qualities, knowledge, and skills in the basic requirements of personal behaviour, as well as technical knowledge and practical auditing skills. Successful auditors also need to be conversant with the:

- Requirements of a safety and health management system such as for e.g. OHSAS 18001, which may sometimes be referred to as the audit criteria
- Applicable and current legal requirements
- Good safety-management practice

The ISO 19011 the guidance document usually used for auditing management systems, differentiates between internal and external auditors.

Internal auditors are generally an organization's own employees who perform first-party audits.

Meanwhile, external auditors, who are not the organization's own employees, perform second- and third-party audits.

- **THE KEY SKILLS FOR AN AUDITOR SHOULD INCLUDE BEING:**
  - ORGANISED, OBJECTIVE, OBSERVANT, A GOOD COMMUNICATOR, DISCIPLINED, WELL TRAINED
- **AN AUDITOR SHOULD ALSO BE:**
  - PREPARED, USE CHECK LISTS, TAKE THEIR TIME, CONTROL THE AUDIT, CONCENTRATE, OBSERVE, LISTEN AND LOOK INTERESTED, OBTAIN INFORMATION BY CONCISE QUESTIONING, VERIFY THE INFORMATION GLEENED, ASSIST CO-AUDITORS, LEARN TO KEEP CALM, PAY COMPLIMENTS WHERE DUE AND SHARE INFORMATION WITH THOSE BEING AUDITED.
  - NOTE:

    IT IS IMPORTANT THAT AUDITS ARE CARRIED OUT IN THE RIGHT SPIRIT AND WITH THE RIGHT ATTITUDE. THIS IS RELEVANT FOR THOSE DOING THE AUDITING AS WELL AS THOSE BEING AUDITED.

- **Auditors' "Do Nots"**

DO NOT:

BE LATE, ARGUE, MAKE COMPARISONS WITH OTHERS, BE SARCASTIC, CRITICAL, BE ABUSIVE, GET SIDETRACKED OR DISCUSS PERSONALITIES.

- **Auditor's skills when seeking information**

Ask:

- WHEN/WHERE IS THIS RECORDED?
- WHO CHECKS THESE RECORDS?
- WHICH PAGE IS THAT ON?
- SHOW ME THE...?

Test understanding

BY USING THE PHRASE:

- MAY I JUST CHECK THAT WE ARE TALKING ABOUT THE SAME THING HERE?

Seek proposals

◊ HOW DO YOU THINK WE SHOULD DEAL WITH THIS TO IMPROVE IT?

Be supportive

◊ YES, I GO ALONG WITH THAT

◊ THAT IS A GOOD IDEA

When questioning an auditor should:

◊ USE SIMPLE LANGUAGE, GET A TRANSLATOR, IF NECESSARY, USE

◊ SHORT SENTENCES,

◊ ASK DIRECT BUT OPEN QUESTIONS AND

◊ NOT AVOID EYE CONTACT.

6.OUTPUTS FROM AUDITS

The following should be required outputs:

- TO HAVE A UNIFORM APPROACH FOR ALL AUDITS AND GIVE POSITIVE FEEDBACK ON THE:
  - ◊ ADHERANCE TO COMPANY POLICIES /COMPANY STANDARDS/PROCEDURES
  - ◊ CORRECTIVE ACTION TAKING PLACE
  - ◊ IMPROVEMENTS TAKING PLACE
- TO HIGHLIGHT AREAS FOR IMPROVEMENT

  NOTE: THESE SHOULD INCLUDE SYSTEMS' DEFECTS OR NON-COMPLIANCES WHICH MAY LEAD TO A NON-CONFORMANCE
- TO GIVE FEEDBACK ON PREVIOUS UNPLANNED EVENTS (DUE TO NON-CONFORMANCE
- TO LIST THE REQUIRED CORRECTIVE ACTIONS.
- TO FOLLOW UP ON THE CLOSE OUT OF CORRECTIVE ACTIONS TAKEN.

BELOW THE REFERENCE "Process Safety Auditing European Process Safety Centre REPORT 32", STATES THAT:

"Taken as being a high-level process of validation and investigation, it is unreasonable to expect an audit to find everything. An audit cannot be said to have failed if later a significant but low-level flaw is discovered. **The audit will give an overview of safety performance, not guarantee safe operation**.

However, an audit programme **could be seen to fail if systematic problems are present over multiple audits, remaining uncorrected**. A less significant form of failure could be the lack of improvement that would follow from a stagnant audit programme acting in a poor safety culture.

SODIUM NITRITE

By

Paul Harrison.

An excellent presentation was given in the SAFEX Webinar No2 on the hazards associated with sodium nitrite. Following on from the presentation, I wish to add some further comments based on my experiences in handling sodium nitrate which SAFEX members may find useful.

1. Check to ensure that sodium nitrite is not deemed a scheduled poison in the jurisdiction in which you operate. If so, additional storage and record keeping requirements to those normally required for dangerous goods may apply (eg must be kept under lock and key at all times, qualified responsible officer appointed, etc).
2. On receipt carefully check that the associate delivery dockets and the consignment match. Sodium nitrite, sodium nitrate and ammonium nitrate are all Division 5.1 dangerous goods and carry the same yellow diamond on packaging. External warehouses and freight companies may not fully appreciate the subtle additional precautions that must be taken in handling sodium nitrite. Few fully understand UN Numbers.
3. Train those handling sodium nitrite, sodium nitrate and ammonium nitrate within your plant/factory to recognise the physical differences of these chemicals. The differences are generally obvious when compared side by side. If an operate does notices differences these should be immediately reported before use.
    - Ammonium nitrate is white and normally handled as a prill. Plants may handle a crystalline form. Both forms may have a slight ammonia smell.
    - Sodium nitrate is also white, normally crystalline and can be quite lumpy.
    - Sodium nitrite is usually off-white in colour with an orange/yellowish ting and is usually a fine loose powder.

   Appreciating the physical characteristics of sodium nitrite and sodium nitrate can be critical especially if bags are poorly marked or markings are difficult to read.
4. Solutions made with sodium nitrite should be appropriately coloured with a compatible dye for easy identification.
5. Storage areas for sodium nitrite should be appropriately identified and labelled. Basic information sheets providing safety requirements in handling sodium nitrite and procedures to be followed in an emergency should be posted. These must be in the language of the operators.
6. Detailed Safety Data sheets must be readily available to all.
7. Appropriate procedures must be in place for the collection and disposal of waste solid and solutions of sodium nitrite. Waste containers must be clearly labelled. Possible cross contamination with ammonium nitrate waste must be avoided.
8. Appropriate procedures must be in place for the disposal of sodium nitrite packaging material. Possible cross contamination with ammonium nitrate packaging must be avoided.
9. All employees should be trained and fully appreciate the hazards associated with sodium nitrite.

Musings From Western Australia

By

Ken Price

Trainspotting

At the time of the last SAFEX webinar I was part way through a job for a major Australian rail company, reviewing their procedures and practices for transporting dangerous goods. As part of the job I was observing them marshalling wagons and forming up trains. This is a job in which various runs of wagons are assembled in a particular order to ensure appropriate separation distances between tanks of incompatible dangerous goods. It's not a very good idea to run containers of ammonium nitrate next to petrol tankers for example. Or acid tanks next to cyanide wagons.

The shunters who coordinate this operation are working at the ends of the various parts of the train, checking that the wagons couple together properly and then they must get between the wagons to connect the pneumatic hoses that power the brakes.

It's not a job for the faint hearted and the shunter has her life in the hands of the driver who may be a kilometre away. And both rely on adherence to safety procedures developed over many years with consistent and frequent communication between both parties.

I couldn't help but think of the accident involving the "spotter" on the blast site who was run over: the driver only became aware that he had reversed over the spotter when he appeared at the front of the truck. Fortunately, not a fatal accident but very scary.

The explosives company did a full review of the accident and have changed their procedures but after watching the train operation my mind went into overdrive with a few questions you might like to consider.

When you have a spotter, who is in control, the driver or the spotter? If the latter, the driver shouldn't move without instruction from the spotter. If the former, what exactly is the job of the spotter? Perhaps to tell the driver when he has run over someone?

What is the role of the spotter? To guide the truck, or to clear the way? In either case, how does the spotter tell the driver where to go or about any obstructions? Or is the spotter just there to help pick up the pieces when something goes wrong?

In the rail operation I observed, the shunter is not allowed to cross the rail track without clearance from the train driver. And the train driver is not allowed to move without clearance from the shunter.

Has anyone seen a new accident report lately?

I haven't. But I've seen quite a few old ones recycled.

Like the large number of people killed in Ghana around an explosives vehicle despite the driver trying to warn people to stay away. Does that remind you of Celamania, Mexico in 2007? Or USA in the 1970's? Or Angellala Creek in Queensland in 2014.

Like the explosion in Beirut. Does that sound like Texas City 1947? Or Brest? Or Toulouse? Or West?

When will we see the next container of fireworks detonate? It's been a year or two. Fireworks classified 1.3C, fire hazard, but put them in a steel freight container and we have another Enschedde, or Kolding, or Carmel. We all know that fireworks can detonate when in freight containers, but we forget. And almost no-one wants to recognise this fact and label the containers as mass explosive. (Most Australian states have taken this step. The stuff arrives classified as benign and the arrival state will require placarding to recognise the mass explosion hazard.)

Who knew that old propellants are unstable and are likely to spontaneously explode? Many people actually and they told me so after I circulated details of an unexpected explosion of a propellants magazine in New Zealand recently. But unfortunately, the people who should have known, didn't. They had broken down some old ammunition and stored the propellant for too long and off she went.

Who knew that those nice little shotshell primers that sit so safely at the end of small arms ammunition could be so dangerous when you put a load of them into a hopper? Not the people who loaded a hopper and then learned when the load detonated. Any cartridge manufacturer could have told them.

Does anyone still use nitroglycerine based explosives? In the mining industry, we no longer require brooms in magazine vestibules or require people to wear galoshes to avoid friction anymore. And it is common to see exposed steel in magazines. But NG has a habit of finding a way out of cartridges and smearing itself on surfaces. Don't find out the hard way.

Similarly, does anyone use safety fuse to initiate blasts? Safety fuse is not so safe. I know of several premature explosions that have occurred when safety fuse burned like instantaneous fuse. Don't use safety fuse unless you are satisfied that you are in a safe position if the shot fires at the time you ignite the fuse.

Explosives are not safe, just safer. All explode when given the right stimulus.

What's the difference between an article?

Or less Zen-like: when is an article not an article?

Those of us familiar with the Globally Harmonized System for Classifying and Labelling Chemicals (the GHS) should be aware that GHS doesn't apply to articles. Reference GHS:

1.3.2.1.1 The GHS applies to pure substances and their dilute solutions and to mixtures. "Articles" as defined in the Hazard Communication Standard (29 CFR 1910.1200) of the Occupational Safety and Health Administration of the United States of America, or by similar definition, are outside the scope of the system.

And most explosives are articles. Boosters, detonators, small arms ammunition, cartridges, igniters, primers etc. All of these would fall within the definition of an article in 29 CFR or the definition in any dictionary.

However, since its inception GHS has had chapters on explosives classification and labelling. These were supposedly a reflection of the requirements in the United Nations Model Regulations for Transport of Dangerous Goods (the Orange Book).

Most of the explosives industry was happy to live with this anomaly, confident that all their classification and labelling systems achieved a satisfactory level of safety and complied with relevant national explosives laws. That was until governments started to implement GHS nationally and intrude on the existing systems for labelling.

To accommodate this dichotomy, GHS chapter 2.1 has been redrafted to make it workable for the explosives industry, and in doing so it was necessary to resolve the anomaly of GHS and articles. Hence the term "explosive article".

The GHS applies to explosives, including **explosive articles.**

Explosive articles aren't articles.

Got it?

Enhancements in Version 2 of the Scenario and Target-Relevant Explosive Equivalence Tool: STREET

by

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ABSTRACT

Explosive equivalence is an expedient method for estimating blast loads from explosive charges composed of something other than a standard reference material. By using explosive equivalence, the weight of the given material can be converted to an equivalent weight of a standard reference material that has been extensively characterized in terms of blast pressure and impulse as a function of scaled standoff. While approximate, this approach is straightforward and has been implemented in numerous government manuals, including UFC 3-340-01 and 3-340-02.

In recent years, the STREET tool was developed as a means of collecting explosive equivalence data from numerous individual sources into a single easily accessible software package. The tool was initially released in 2016 but has now been released as version 2.0 with additional functionality and enhanced features. The primary enhancement allows the user to calculate equivalent weight not only with regard to TNT (the typical standard reference explosive) but also Composition C-4. A number of new materials have also been added to the database, which now covers 148 different explosive compositions. The majority of these are improvised or home-made explosives (HMEs), but some are munitions grade explosives. The STREET tool captures the sensitivity of equivalence to scaled standoff, a feature most strongly evident for HMEs, and it also provides estimates of uncertainty based on the scatter in the test data. It now provides reference data in tabular form from a dozen published references (government manuals and textbooks), which can be compared to the test data at the heart of the database.

This paper explains the principles underlying the code, particularly the methodology used to calculate C-4 equivalence; gives an overview of the data contained; and illustrates the code's functionality. By using STREET, analysts, scientists, and engineers will have ready access to a comprehensive collection of equivalence data for a wide range of explosive materials.

INTRODUCTION

In general, every explosive material requires specific characterization in order to define its properties and effects, such as blast parameters. However, only a handful of such materials have been properly characterized so that their explosive effects are well understood and can be predicted with widely available engineering models. TNT has been the explosive for which the most widely accepted models are available. The most commonly used engineering model for predicting blast effects from TNT is that developed by Kingery and Bulmash (K-B) in the late 1980s [1].

To predict the effects of an explosive other than TNT, the material must first be converted to an equivalent weight of TNT before applying these K-B curves. This assumes that a relationship like the following applies:

$$W_{TNT-equiv} = KW_{mat} \tag{1}$$

where W_{mat} is the weight of the material, K is the equivalence factor, and $W_{TNT\text{-}equiv}$ is the equivalent TNT weight. Note that K will, in general, be different for pressure than for impulse, and is not necessarily a scalar, but could be a function of other parameters such as scaled standoff.

Some communities involved in explosives engineering use Composition C-4 as a reference explosive in addition to (or in place of) TNT. Conversion via equivalence factors from an arbitrary material to C-4 proceeds in an analogous manner, albeit with different K factors.

BACKGROUND AND UPDATES IN V.2

In recent years, the Technical Support Working Group (TSWG), with the participation of the Department of Homeland Security (DHS), the Federal Bureau of Investigation (FBI), and the Singapore Ministry of Defense, sponsored a program to develop the Scenario- and Target-Relevant Explosive Equivalence Tool (STREET). The objective of the STREET program was to develop a decision support software tool that guides users through a step-by-step process to run explosive equivalence calculations in support of engineering design and scientific applications. Version 1 of STREET was released in 2016. As the program evolved, more specific objectives were enumerated and refined. This included, in large part, allowing users to calculate equivalence relative not only to TNT, but also C-4. In addition, the experimental database was expanded, and the data from the reference manuals has been separated from experimental data and is provided in tabular form. This paper presents an overview of the changes to STREET v.2 and methodology used to calculate C-4 equivalence.

The STREET tool was intended to serve two communities with somewhat different needs and interests—engineers and scientists. Engineers can use the tool to rapidly obtain equivalence values at the start of a blast-resistant design project in order to use an appropriate charge weight in calculating blast loads for various components of a building. Scientists involved in explosives research, however, are more likely to look for detailed data, uncertainties, and comparisons to similar materials, or to locate other background information.

To satisfy these dual needs, STREET was released in two versions. The version with full functionality, including the ability to view the original source data, is restricted to government agencies and their contractors. STREET-Lite is generally available to architects and engineers involved in blast design. Software distribution is being handled through a web site being maintained by TSWG, as referenced at the end of this paper.

STREET provides equivalence values for pressure and impulse, as well as for brisance. Brisance is applicable for contact bursts, while pressure and impulse equivalence are useful for standoff bursts where airblast parameters need to be calculated. Since brisance equivalence has no standoff dependency and is seldom applied in design situations, brisance data was simply obtained from tables in a standard reference [2], while the bulk of the effort was devoted to characterizing standoff-dependent pressure and impulse equivalence for as many explosives as possible.

The approach used in defining pressure-impulse equivalence for STREET is purely empirical. That is, rather than considering the heat of formation or the chemical properties of the compound to extract a theoretical energy content, equivalence was obtained from experiments conducted in which the subject explosive was detonated, and pressures/ impulses were measured as a function of standoff. Ideally, that data was then compared to TNT data from a similar configuration of charge size/shape/location in order to determine the weight of TNT that would produce the same amount of pressure/impulse at each standoff. In some cases, TNT tests were not conducted; instead, equivalence was estimated by reference to standard models for pressure and impulse, such as Kingery-Bulmash [1]. This is a less reliable approach by far, due to the fact that Kingery-Bulmash only provides data for two highly idealized geometries (sphere in free air or a hemisphere at ground surface), while the tests are often conducted using cylindrical charges placed at some height above the ground. As a result, errors were introduced into the equivalency estimates due to other effects such as charge geometry and reflections from the ground.

Version 2 of STREET, released in the summer of 2019, improves upon the earlier version 1 in three important ways:

1. Users now have the option to obtain pressure/impulse equivalence (for standoff bursts) in terms of C-4 as the reference explosive, in addition to TNT.

2. Data obtained from reference manuals (such as UFC 3-340-01) was separated from data obtained from experiments. All the curve fits are now based exclusively on experimental data, while manual data is presented to the user in a separate tabular form. In this way, the curve fits are purely empirical, but users can draw comparisons against the published literature if desired. This is a more rationally consistent approach, since manual data is almost always scalar in nature whereas experimental data usually includes the relationship between equivalence and standoff.

3. New experimental data was incorporated in the database, some of it augmenting data for materials available in version 1, but others defining equivalence for previously unavailable materials.

It should be noted as well that STREET is an *equivalence* model, not a *blast* model. That is, rather than outputting pressure or impulse, it provides the user with an equivalent weight of TNT that can then be used in any blast model of the user's choice. This would include very simple models like Conwep, more advanced engineering models like BlastX, or potentially even within a complex computational fluid dynamics (CFD) code. Adjustment factors can then be applied within the simpler models as needed, such as those for casing effects, ambient pressure and temperature effects, or charge shape/geometry.

DATA SOURCES AND OVERVIEW

Two categories of sources were tapped for equivalence data, manuals and experimental reports. A total of 13 manuals and 24 experimental sources were included in version 2 of STREET which almost doubles the sources included in version 1. Half of the experimental sources contained data in terms of pressure and impulse rather than equivalence and required conversion into equivalence by comparing to Kingery-Bulmash for TNT. For the remaining experimental sources, the data was processed by the original experimenters to produce equivalence per their own analytical methods.

The data gathered from all new experimental sources was added to the Access database created for version 1. The database now contains information for a total of 382 explosive materials and/or mixtures. The data falls into three categories: (a) brisance, (b) standoff from manuals, and (c) standoff from tests. The number of materials that fall into each of these categories is provided in Table 1. Note that the sum of the numbers in that table (166 + 114 + 148 = 428) is a higher number than the 382 cited earlier. That is because some materials have data in two or all three categories (e.g., both brisance and test-based standoff data). The Venn diagram shown in Figure 1 breaks down the number of materials that are unique to each category as well as how many have data from two or all three categories. It also shows the division of the 148 materials with experimental standoff data into two categories, HMEs and munitions grade (MG), indicating that the vast majority of explosives with experimental data are HMEs.

Table 1. Overview of explosives in STREET database.

	Manual	Experimental
Brisance	166	—
Standoff (pressure and impulse)	114	148

A listing of the published manual sources included in version 2 of STREET is shown in Table 2. The list includes books, technical papers, well-known manuals from various government and military agencies, and standards published by industry associations.

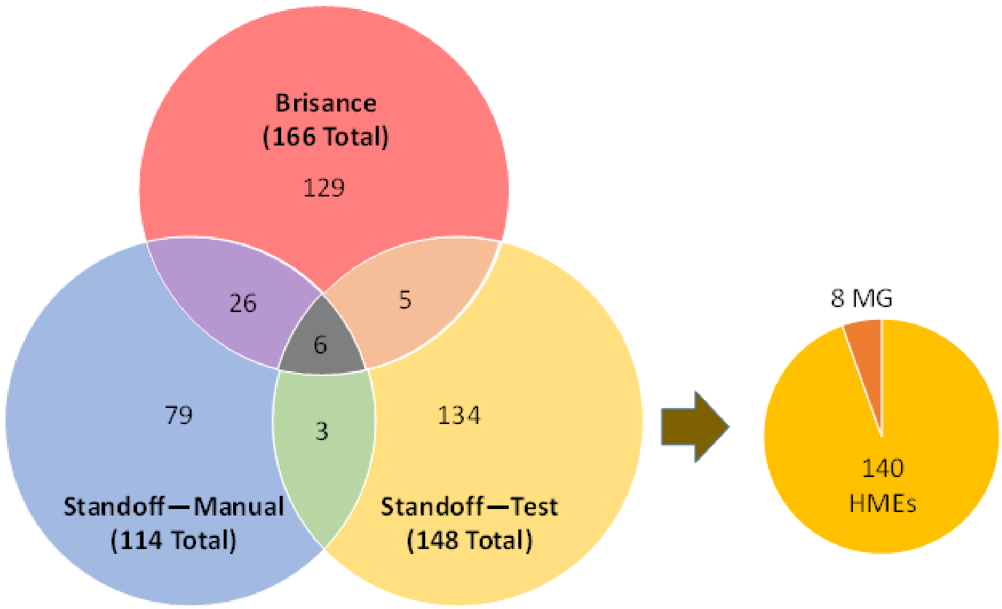


Figure 1: Breakdown of explosive materials in STREET.

Table 2: Manuals with equivalence data referenced in STREET v.2.

Source	Issued by	Year
AMCP-706-177	US Army Materiel Command	1971
Swisdak, "Explosion Effects and Properties"	Naval Surface Weapons Center	1975
Gould, "High Explosive Field Tests"	Kaman Sciences/DNA	1981
MP 88-116	Naval Surface Warfare Center	1988
DOE/TIC 11268	Department of Energy	1992
Cooper, "Comments on TNT Equivalence"	International Pyrotechnics Seminar	1994
Marchand, "A Design Guide and Specification for Small Explosive Containment Structures"	SwRI/Sandia	1994
Cooper, *Explosives Engineering*	VCH Publishers	1996
UFC 3-340-01	Department of Defense	2002
IATG 01.80	United Nations Office for Disarmament Affairs	2011
ISO 16933	International Organization for Standardization	2012
UFC 3-340-02	Department of Defense	2014
Technical Paper 17	Department of Defense Explosives Safety Board	2016

STANDOFF EQUIVALENCE METHODOLOGY FOR C-4

The primary enhancement to version 2 of STREET is the feature that allows the user to calculate equivalence relative to Composition C-4. Note that equivalence relative to C-4 is only available for those materials that have experimentally derived data in the database; it is not available for materials that only have manual data for standoff, or that only have brisance data.

There are two ways to determine C-4 equivalence, a direct method and indirect method. The direct method is the most robust, but it involves establishing a standardized blast model for the reference material (analogous to Kingery-Bulmash for TNT), comparing the raw pressure and impulse measurements to the standard model and re-calculating the equivalence, as well as storing the data points separately and performing an entirely separate set of curve fits to represent these points. The direct approach is problematic, however, as there is currently no standard blast model for C-4 that is accepted in the community, and in many of the data sources, the reports provided equivalence (relative to TNT) but do not provide the raw pressure and impulse values. Therefore, even if a model was available, C-4 equivalence could not be determined.

An indirect approach was therefore used to add C-4 equivalence to version 2 of STREET, as illustrated in Figure 2. Every material in STREET (including C-4) already has equivalence defined relative to TNT. By inverting the C-4 to TNT relationship, any material could be first converted to TNT, and then from TNT to C-4. This required having a well-documented and robust relationship from C-4 to TNT. However, version 1 of STREET only contained C-4 data from 3 sources with a total of 19 pressure data points and 29 impulse data points, which was hardly sufficient. Therefore, several new sources were added to the database, resulting in 261 pressure data points between scaled standoff of 0.5-104 ft/lb$^{1/3}$ and 319 impulse data points between scaled standoff of 0.2-104 ft/lb$^{1/3}$.

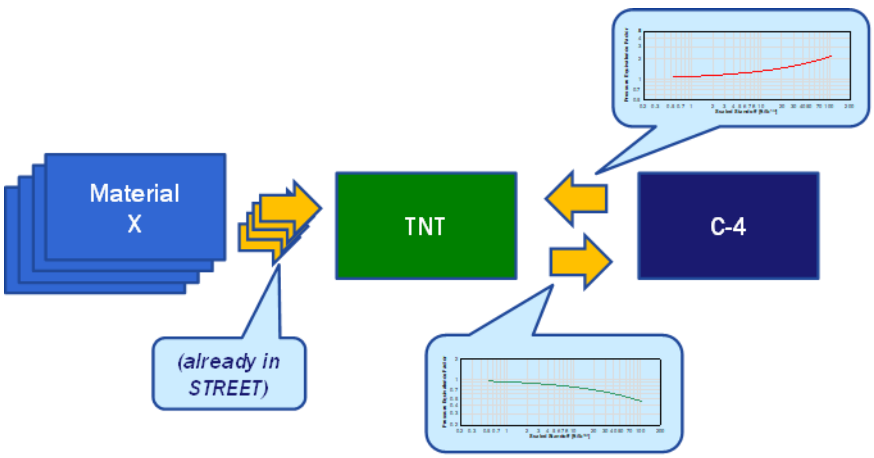


Figure 2: Composition C-4 equivalence approach.

Having established a robust relationship between C-4 and TNT, a C-4 equivalence curve for TNT had to be developed. The TNT equivalence curve for C-4 is a function of scaled standoff [*f*(*Z*)]. This scaled standoff is the standoff, *R*, divided by the cube root of the charge weight of C-4, W_{C4}:

$$Z = \frac{R}{W_{C4}^{1/3}} \qquad (2)$$

The inverse relationship is not simply the inverse of the TNT equivalence curve. That is to say, one cannot use the curve 1/*f*(*Z*) to go back from TNT to C-4. The inverse curve is a function of scaled standoff [*f*(*Z'*)], with the standoff *Z'* being divided by the charge weight of TNT and not C-4:

$$Z' = \frac{R}{W_{TNT}^{1/3}} \qquad (3)$$

The charge weight of TNT is the product of the equivalence factor and the charge weight of C-4. By converting the scaled standoff in terms of the C-4 charge weight, we get a scaled standoff of the following:

$$Z' = \frac{R}{(KW_{C4})^{1/3}} = \frac{1}{K^{1/3}} \frac{R}{W_{C4}^{1/3}} = \frac{1}{K^{1/3}} Z \qquad (4)$$

Therefore, once the direct inverse [1/*f*(*Z*))] of the curve was taken, a factor of $1/K^{1/3}$ was also applied to the x-values of the curve. The TNT equivalence curve and inverse curve for pressure and impulse are shown in Figure 3 and Figure 4 respectively. The red curves are the C-4 equivalence curve for TNT. These inverse curves are used to develop C-4 pressure and impulse equivalence for each material containing standoff data in STREET.

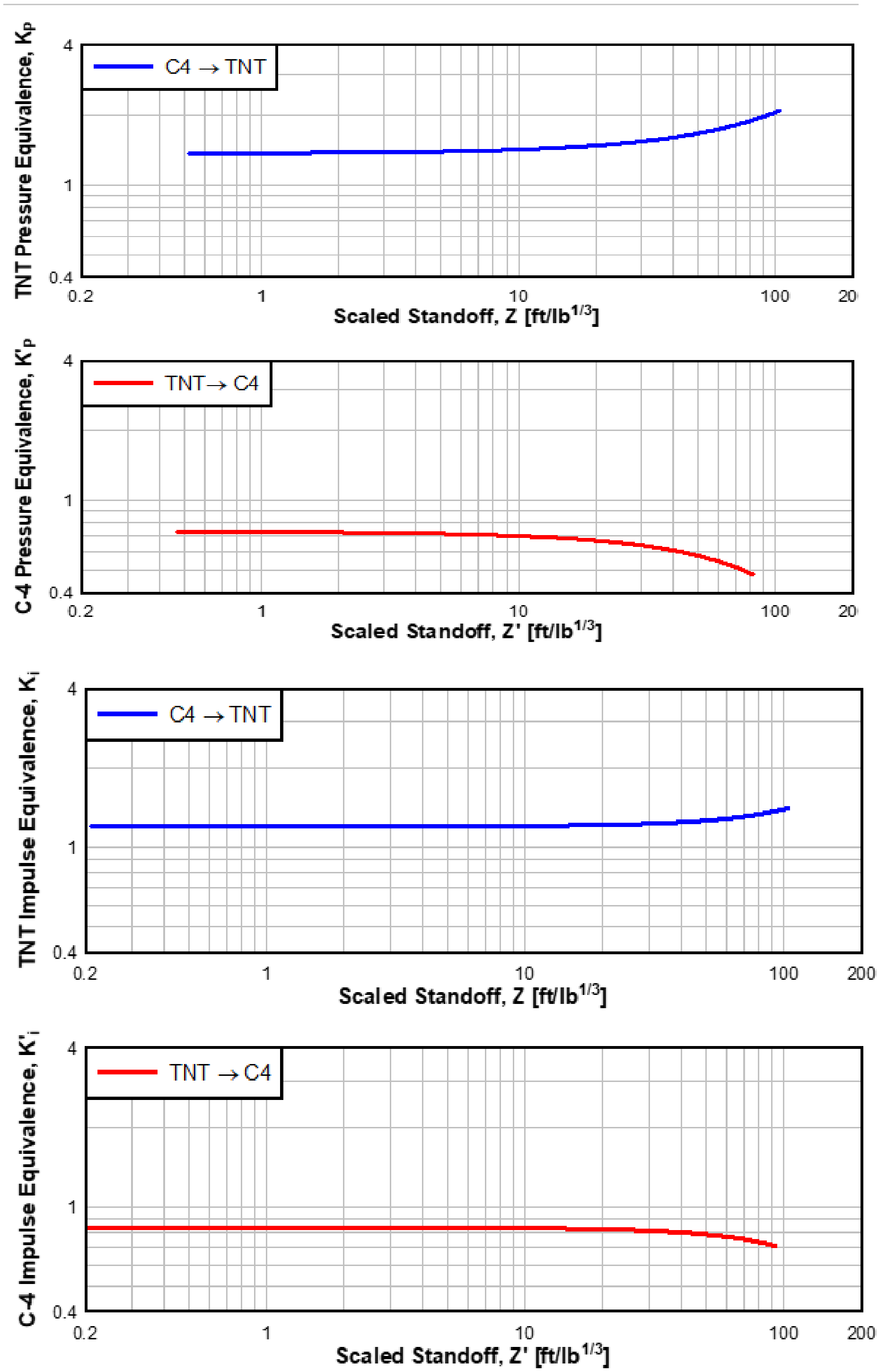


Figure 4: TNT impulse equivalence curve and inverse curve for Composition C-4.

METHODOLOGY VALIDATION

In a few isolated instances, *direct* equivalence from a material of interest to C-4 had been calculated by the researchers performing the tests. This data was of great value in validating the *indirect* C-4 equivalence method used in STREET. Ideally, whether one used a direct or indirect approach (Figure 5), the results should prove to be essentially similar.

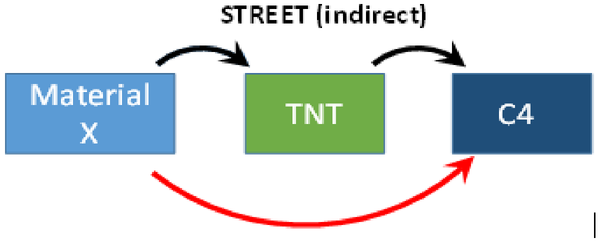
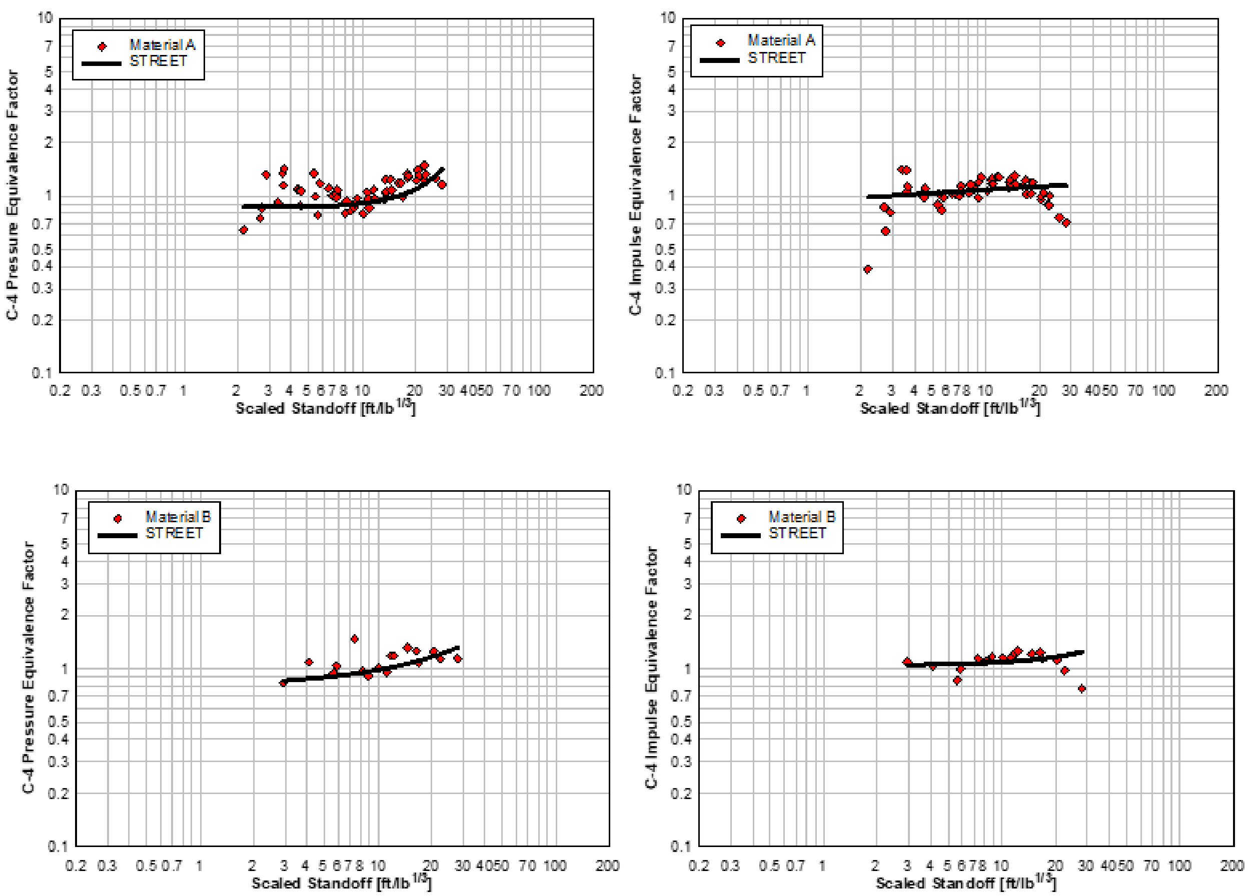
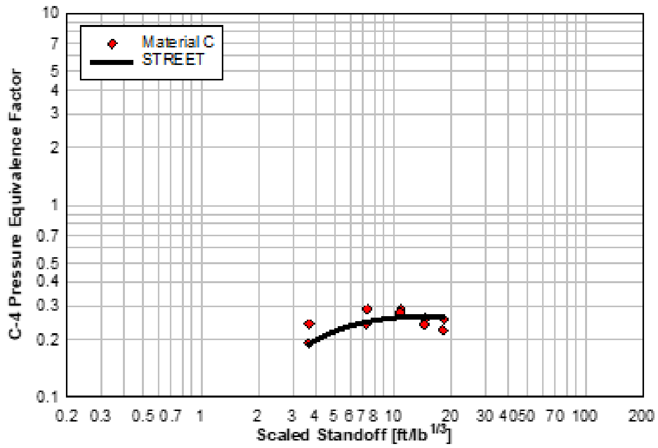


Figure 5: Methods to obtain C-4 equivalence.

To confirm this, the C-4 (direct) equivalence data points were plotted with the STREET (indirect) C-4 curve fit for several materials, as shown in Figure 6. The data is plotted in red markers and the STREET C-4 equivalence curve uses the black line. The plots show a very good match between the directly calculated C-4 equivalence data points and the STREET C-4 equivalence curve in all cases, thus validating the method used. A few points seem to be stragglers and outliers, particularly in the impulse data. The direct data seems to suggest a strongly downward-concave relationship, which would be counter-intuitive; furthermore, the points are mostly clustered in the center of the domain, and only a few points at either end of the range drive this curvature. Overall, the indirect method appears to be consistent with the direct results and can be relied upon for the more than 100 other materials in the STREET database.





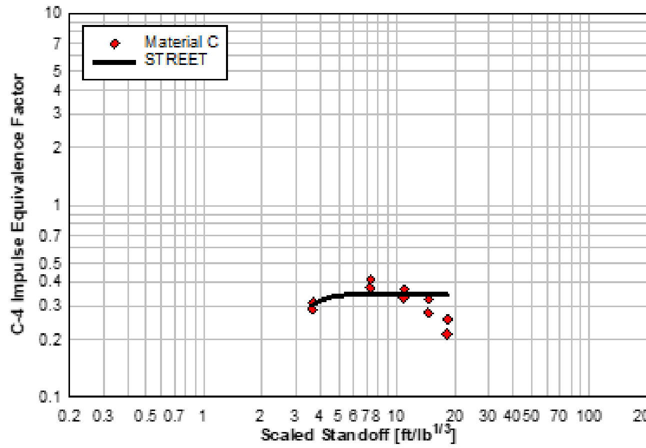


Figure 6: C-4 equivalence validation.

UNCERTAINTIES

It should be noted that a relatively broad scatter of the data points was observed for C-4. The fitting uncertainties for this material (as quantified by the uncertainty factors listed in Table 3) are higher than those for approximately 85% of the remaining materials. This is unfortunate, because it means this high degree of uncertainty will be propagated through into the inverse relationship which will be called upon by any user seeking equivalence relative to C-4. Little can be done to reduce this uncertainty, short of performing a large number of additional tests beyond those already performed, and then hoping that those results will be consistent with those already obtained.

Table 3: Fitting uncertainty for C-4 to TNT equivalence relationships.

	Pressure	Impulse
2σ uncertainty factor	1.55	1.40

By using the indirect method, a second curve (converting TNT to C-4) is introduced into the equivalence calculation, a curve which has its own uncertainties. Thus, in addition to the original two sources of uncertainty (fitting and measurement), a third must be included in the uncertainty calculations, and that is the uncertainty in the TNT to C-4 curve. Table 3 shows that the fitting uncertainties on the pressure and impulse curves are 1.55 and 1.40, respectively, for a 2σ uncertainty. The UF values remain unchanged whether the curves are being applied forward (from C-4 to TNT) or backward (from TNT to C-4). For convenience, this second case will have a conversion uncertainty (conversion from TNT to C-4), UF_{conv}, in addition to the measurement and fitting uncertainties. The total uncertainty factor for a material being converted to C-4 is then represented by equation 5, where the new term is now included in the square root of the sum of squares.

$$U = \exp\left[\sqrt{ln^2(UF_{fit}) + ln^2(UF_{meas}) + ln^2(UF_{conv})}\right] \tag{5}$$

SOFTWARE IMPLEMENTATION

The STREET software and its graphic user interface (GUI) are developed using the Microsoft Windows computer programming language RealBasic to interact with the STREET Equivalence Database that stores all the information required to search and process explosive equivalence.

The v.2 GUI, as illustrated in Figure 7, is very similar to version 1. However, users are now able to select either TNT or C-4 as their reference material when standoff burst type is selected. If the contact burst type is selected, the reference material will automatically be set to TNT. The material can still be selected two different ways. The first way is to start typing text into the search window which then brings up all materials containing that text. Use of the text search will also allow access to those materials that have trade names or acronyms, such as "Amatol" for a mixture of equal proportions of ammonium nitrate and TNT. The second method is to specifically select from the drop-down lists an explosive material, its form, then any additives (or fuels), and finally their proportion.

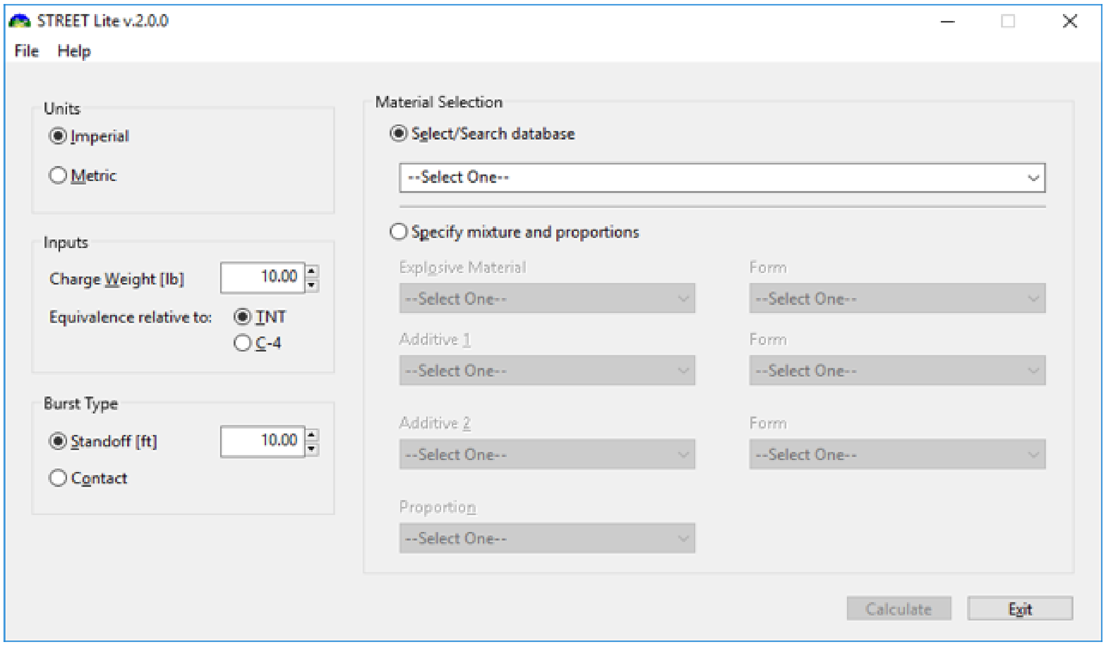


Figure 7: STREET main input screen.

A new feature in version 2 allows the user to view the reference manual data for the selected material in tabular form as shown in Figure 8. This allows the user to compare equivalence data from a number of different manuals to the empirically derived equivalence (given in the results window). The manuals are listed in the left hand column with separate TNT equivalence for pressure and impulse. If a range of application was given in the manual, it is listed on the right hand column. If a user selects C-4 as the reference material, the Manual Results button will be disabled.

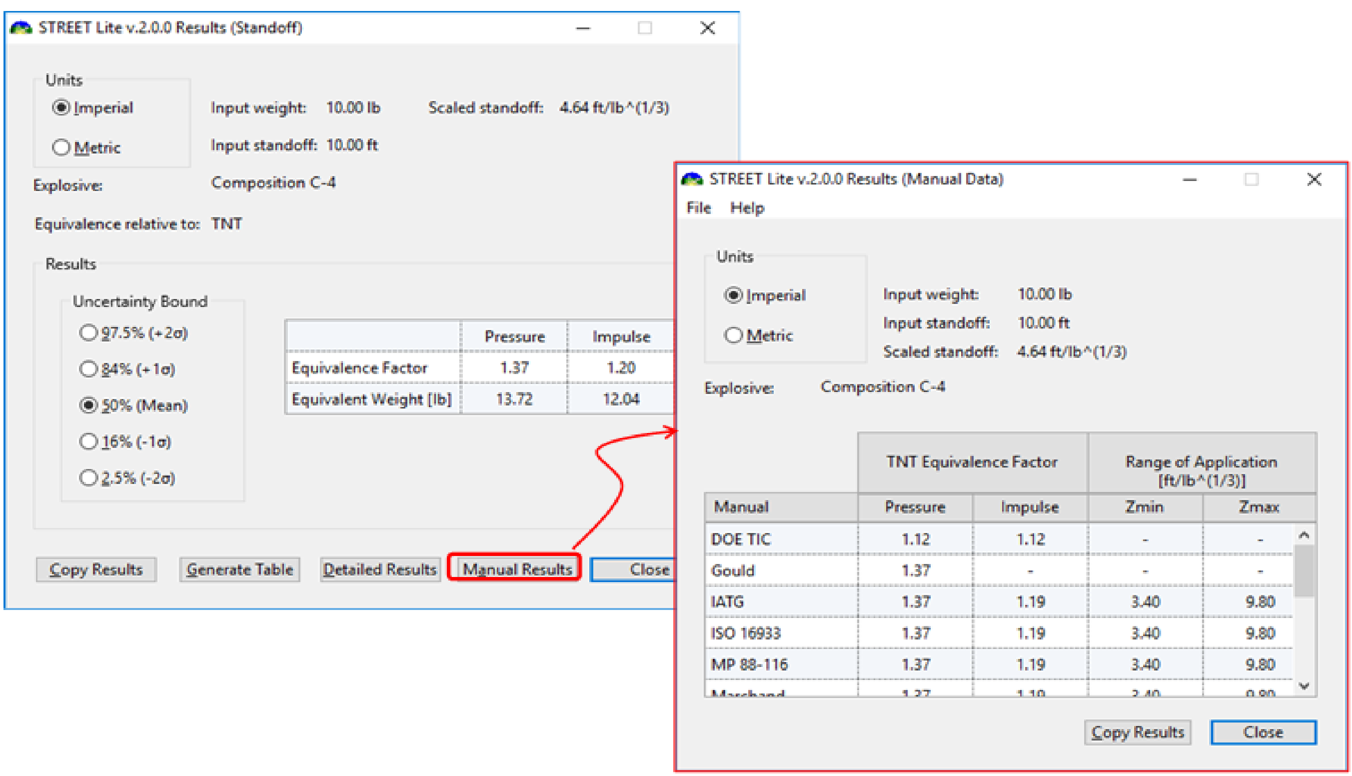


Figure 8: Manual data window.

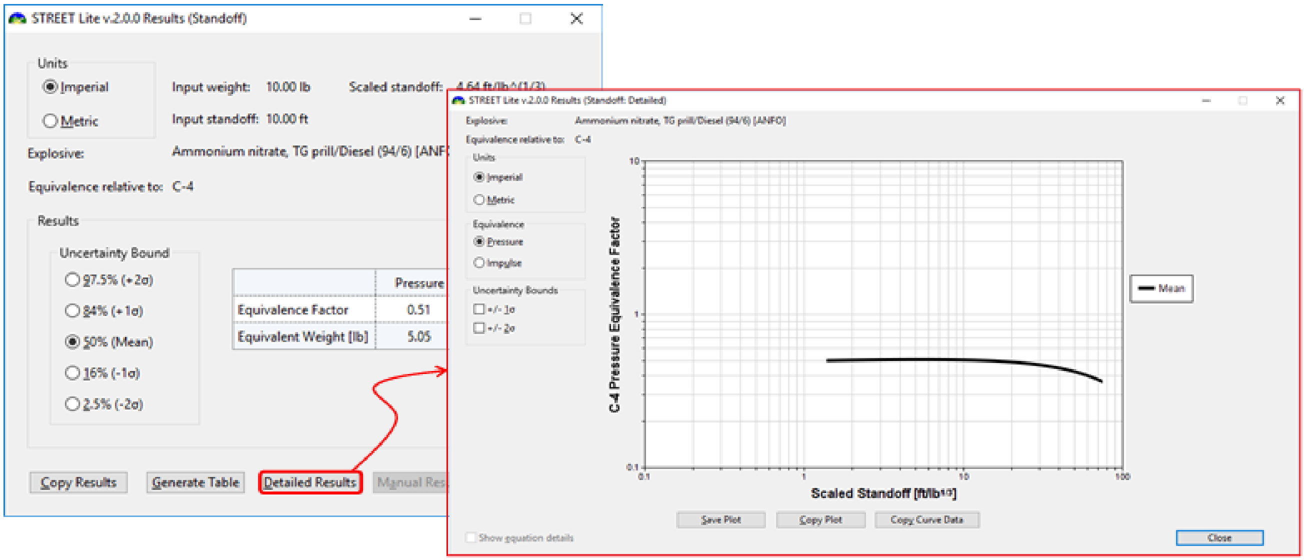


Figure 9: Detailed results window.

CONCLUSIONS

Version 2 of STREET now contains approximately 4,000 individual experimental data points on explosive equivalence, drawn from 24 test reports and papers. Experimentally derived pressure/impulse equivalence can now be obtained for 148 different explosives, the majority of which are HMEs. Data has also been compiled from 13 reference manual sources that provides scalar equivalence for 114 different materials (virtually all of them MG), plus brisance data for 166 materials.

Software may be accessed at this web portal:

- street.cttso.gov

ACKNOWLEDGMENTS

The authors acknowledge with gratitude the support of Mr. Alex Arbizo, TSWG program analyst, and Ms. Elizabeth Obregon, Department of Homeland Security, for the current study.

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[2] B. T. Fedoroff, H. A. Aaronson, O. E. Sheffield, E. F. Reese, and G. D. Clift. *Encyclopedia of Explosives and Related Items, Volume 1.* Picatinny Arsenal, Dover, NJ, 1960.

MISTS AND THICKENED SKIN

By

Tony Rowe

Safety is something our industry takes very seriously. Most of us I'm sure are trying to act in a safe manner, but do we always succeed? I doubt it. Ours is a very complex industry and one that demands an extremely broad knowledge base from its supervisors and safety practitioners. The downside is that everbody makes errors. I certainly have and did. None were intentional or in any way deliberate acts, but in retrospect, all were avoidable.

Most of the time, these mistakes, whether mind bogglingly reprehensible or minor errors of judgement do not lead to significant consequences, but sometimes, just sometimes they do. The trouble is that no-one knows in advance which acts will lead to disaster and which ones won't, neither can we predict the when or the where.

The problem with safety is the number of things that can go awry. They range from the mind-numbingly mundane to those unbelievably long and complex chains of inaction and neglect that lead to those notable disasters that occasionally and disturbingly sometimes follow. Beirut was one such event, but why did it happen? To coin a phrase:

Familiarity, Neglect, Apathy and Contempt.

What does apathy mean? I don't know and I couldn't care less.

I can hear the disagreements already but consider this as a means of illustration. All around us are instruments whose misuse can inflict trauma, pain and death upon ourselves or others. They're everywhere. They're in our homes, our places of work and you can acquire one at most shopping centres. They are often stored in pockets and carried about. I lugged one around for almost 30 years and then, because I could afford to do so, I went out and bought a larger and fancier version. I put the old one into a drawer and some years later followed suit with its replacement. I still have both of them and both still work. Either will adequately perform the functions for which they were designed, the larger version can do more, but it is not necessarily better. Sadly, I no longer require what they can provide, but their brothers and sisters are all around and they comfort me still.

Indeed, these devices are so common that few of us give them any thought at all. They are so taken for granted that little thought or effort is directed towards their safe use.

There are great big ones and exceedingly small ones. Some are bright and shiny, whilst others are corroded and ill-cared for. The range of designs are too numerous to mention. Some are intended for a specific purpose whilst others are surprisingly multifunctional. Many can be collectively grouped as cheap and nasty whilst others remain horrendously expensive. Even the shoddiest of examples will often do the job at least once.

Perhaps, not unsurprisingly, children may have almost unrestricted access to them yet, without exception all are potentially dangerous. Many are also illegal. In some countries their possession in public (without good reason) can result in a prison sentence.

They have been around in one form or another since the dawn of time. Sometimes as a best friend and just as often, an unsmiling enemy. Once they were probably simply found or adapted from shells, corals and certain types of rock. Later, in the fullness of time they became actively manufactured. They're called knives. Treat them carelessly at your peril.

Have you ever cut yourself with a knife? I have. I still bear a 2 inch long, horizontal scar on the upper surface of my left thigh. It happened while I was cutting a new tick and flea collar to the length appropriate for my dog's neck. The razor-sharp blade of my Swiss made pocket knife made light work of the tough polymer of the collar, but in anticipation of sterner resistance, I had applied far too much force. Worse, and I should have known better, I was slicing downwards towards my own leg and a couple of other treasured accessories. After slicing through the plastic collar, it then did the same to me, cutting through my trousers and skin and into the muscles of my thigh. Did it hurt? You are danged tootin' it did. There was also a fair amount of blood which tended to colour things, mostly red, as I recall.

There is a word for what happened though.

Carelessness.

Here is another example warranted true. A friend of mine recently bought his 9-year-old son a knife. It was not an expensive knife by any standards, but in his haste, Dad forgot a few things. Blade security, guidance and training to name, but three.

The youngster, playing with the knife in bed managed to somehow slash open the base of his thumb. It was a not insignificant injury and panic followed.

Dee-dah, dee dah. No, not really. It was only a dad's car so no blue lights, but I suspect the air around the driver may have had a bluish tinge. The car nevertheless drove really fast. Some hours at a nearby hospital and a few stitches later, things had calmed down. The knife though was never seen again. Fingers point at Mum, but who can blame her? The weapon wasn't going to get a second bite, not if she could help it.

In retrospect Dad was incredibly foolish. He didn't think, but isn't that the root cause of most accidents?

Is there a word for that too?

Complacency

The point is simply this: Knives are so commonplace that we have almost entirely lost our sense of caution around them. We can illustrate this with a tour of the average kitchen. Really sharp kitchen knives, should, when not in use, be stored out of reach of children in a wooden knife block. A knife block is essentially a scabbard, one of the earliest and simplest safety precautions applied to knife handling. If you haven't got a block, but do have children, then sharp knives should be stored in a closed drawer.

Consider that most of the young adult or teenager type stabbings in the world are not carried out using expensive, designer blades, but rather with cheap, plastic-handled steak, or other kitchen type knives obtained from the home. Are your children carrying knives and how would you know? Even terrorists, denied access to guns or explosives, will often turn to knives. The ubiquitous 10" bladed, chef's knife being a firm favourite.

Are your knives accounted for and safely scabbarded in a block, or in a drawer or are they left lying around on a worktop somewhere After use and cleaning, do we always return them to the block or do we leave them out where others can access them? If you have small children remember, little hands are everywhere. Are your knives stored out of reach or left in open drawers for easy access? Do you wash the sharp ones separately or just turf them into a bowl full of water regardless? Do you always use a wood or plastic cutting board?

What do you do if you drop a sharp knife? Catch it at once or let it fall and get out of the way?

I hope you answered let it fall, but instinct is a hard taskmaster and many of us will make a grab for the weapon Yep. I said weapon. Grab the handle and all may still be well, but if your fingers close around the blade then the first aid box (or worse) may be your next port of call.

Regardless of the task in hand, often the first knife we pick up will do. Knives become screwdrivers, levers, wedges or worse and as a final point here, please don't hand a knife to anyone. Rather place it down and let them pick it up.

In the sometimes strange and complex world of energetic materials a similar psychology can hold sway. Personnel exposed on a daily basis to these materials and devices can become much braver than you can imagine. They may learn that their mistakes and transgressions are not immediately punished by traumatic amputation, death or some horrific burn injury. On the contrary, most of the time when things go awry, nothing happens. The perpetrator may look around to check if they were seen, but basically, it's a deep sigh of relief and back to business as usual. Although they're engaging in a form of Russian Roulette – click, click, BANG, the stats are probably in their favour, but those odds shorten every time someone, somewhere gets away with a similar transgression. Surviving an incident also reinforces our sense of invulnerability, but in reality, the odds are getting shorter. Next time may be the last time.

This process of coping is called learning, but there is a parallel activity occurring alongside.

Learning can generally be an advantageous exercise, but it can come with a downside, I like to call the negative side of a learning process "Callus Theory" as it reflects an emotional hardening of the thought processes similar to the way skin thickens in response to repeated rubbing or impact pressure. It comes in the form of calluses or corns on hands and feet.

If you have read Ian Fleming's James Bond you may recollect Oddjob, a muscular Korean martial arts fighter and personal bodyguard to Mr. Auric Goldfinger. Oddjob had through years of hard physical training built up tough layers of keratin thickened skin on the striking surfaces of his body. His hands could indeed kill. Combined with his legendary steel-brimmed bowler hat, Oddjob was clearly formidable and certainly a force to be reckoned with.

I know, I know, I'm off on a tangent. Thank-you. As usual, I digress.

Back on track.

In a similar way constant and repeated stressing of the thought process soon results in thickened layers of emotional protection. It is no longer keratin, but a rather a thick fog. Affected personnel become somehow less sensitive, their eyes become blinkered, minds grow more resistant and less able to perceive local hazards, but better able to cope. The once superhighway of health and safety has by now narrowed to a single rutted track meandering uphill and surrounded by impenetrable forest. If left untreated the thickening mists of apathy will soon roll in, obscuring even the blindingly obvious.

Too long spent within any environment can have a similar effect. It is not stressing this time, but familiarity. Careless behaviours may increase and worse, people will walk past hazards they could have and should have seen. To illustrate the point, I shall discuss the issue of a small key-lockable safe. It was a quality product manufactured from thick steel. The safe was used for many years as a sort of local expense magazine in which to store sensitive explosives.

Picture this safe sitting unobtrusively on a workbench, but with significant quantities of primary explosives stored, hidden inside. The door would be opened and closed (requiring locking and unlocking) often many times a day. Primary explosives were constantly going in and out, yet nobody saw any hazard. I never saw the safe cleaned – ever.

Were we all blind?

No, just suffering from callus syndrome. It had become so normal. New starts were introduced to the safe by their immediate supervisors and given verbal training in its use. The apparently "safe" use of the safe was thus established in trainees' minds from that time forwards. They, in turn would then train the next generation. This was not some mad scientist's plan to brainwash workers, but it became a perfect, but unintentional route to what amounted to institutional blindness and the inevitable outcome of callus syndrome.

Eventually after much muttering from the backbenches the safe was dispensed with. I would like to say that everyone agreed with the safe being removed, but there were dissenters, mostly folk who had used the safe for years and could see no wrong.

The safe itself was later destroyed in a test blast where 100 full strength detonators were fired within. For the purposes of the test the detonators were first placed inside and the safe door carefully locked closed. With the technical staff and observers well protected within a place of safety, the detonators were initiated. The results as I recall were impressive.

The lesson: It is never wise to store explosives within conditions of high confinement.

The majority of us, whatever our particular walk of life, will develop the symptoms of callus syndrome. It is an insidious process, one as patient as a Chinese brick and about as inscrutable. It simply takes time. It is why in the home environment few people see knives as dangerous objects or even weapons.

Is there any treatment?

Raising of Awareness
Use of Signage
Constant Vigilance
Training

Further. Encourage people to come forward and describe in detail the near misses or unforeseen occurrences they have experienced. A near miss is when an accident or incident is narrowly avoided. There are far more occurring than are actually being reported. Ask people to discuss their own experiences, but don't expect an open or indeed honest response. That will take time and the establishment of trust. Do not punish those who do come forward whatever the horrors revealed, rather reward them, not financially I hasten to add. A new overall or dustcoat plus with a framed certificate is probably appropriate, but they should be presented publicly.

Blasting in mining operations under extreme conditions with Igneo™

By

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The island of Niolam (often referred to as Lihir) is the main island of the Lihir archipelago, which belongs to Papua New Guinea and is located some 900 km northeast of the capital : Port Moresby. The archipelago was formed by volcanic activity about 3.5 million years ago and Niolam is characterized by several volcanic craters, the youngest of which is the caldera of Luise volcano. In this geothermally active environment, about 350,000 years ago, hydrothermal fluids dissolved gold and other metals from deeper rocks and deposited them in veins in higher rocks. This process continued for tens of thousands of years, forming the Ladolam gold deposit. This deposit belongs to the epithermal gold deposit type, of which Ladolam is the largest with approximately 37 million ounces of gold. Globally, this deposit ranks 5th among the largest known gold deposits.

Picture 1: Lihir-Goldmine Camp, Lihir, PNG.

Today, the Lihir Gold Mine is located in the semi-open crater of Luise Volcano. There, the deposit has been mined from the surface since 1997 and produces about 75kg of gold per day. The high geothermal gradient, caused by ancient volcanism and the location at an active plate boundary produces a large amount of geothermal energy, which supplies large parts of the island and the gold mine with energy. However, the geothermal gradient also poses technical challenges: the temperature in boreholes for blasting ore is 125°C, significantly exceeding the maximum

DynaEnergetics, one of the world's leading manufacturers of high-temperature initiation systems for deep wells, was commissioned by the operator of the Lihir Gold Mine, the Australian company Newcrest Mining, to develop an initiation system that would withstand the high temperatures and guarantee safe and reliable operation.

In cooperation with Newcrest, DynaEnergetics developed a new initiation system. This was based on existing Intrinsically Safe™ (IS2™) technology, proven millions of times over in high-temperature conditions in oil and gas wells. The patented IS2™ high temperature system operates digitally and is immune to stray currents and radio waves (RF-Safe), which guarantees a high level of safety.

Picture 2: Open pit of the Lihir mine with view of the Pacific Ocean

Due to the extreme conditions of the Lihir Mine, the existing detonator technology was further developed and the Igneo™ System was created. This includes the HTD150 electronic detonators, optional booster charges when using bulk emulsion, a digital shooting panel, and a programming and testing device.

The HTD150 electronic detonators have a temperature rating of 150 °C over a 48-hour period at a pressure of 3 bar. The copper sleeves of the detonators also feature an additional coating that provides increased corrosion protection under the highly oxidizing conditions when using bulk emulsion. The detonator is connected to the ignition line via a two-core, 10 m long cable with double sheathing of TFE and PUR, which provides the necessary robustness for the harsh environment. The connection to the bus line is made by a splash-proof clip connector.
The ignition interval of the HTD150 detonator is between 1 and 1500 ms in 1 ms intervals freely programmable.

Picture 3: Igneo™ system components: Shooting panel, detonator with booster charge, detonator without booster, programming, and testing device (from left to right).

For improved initiation of the main charge, an optional encapsulated booster shaped charge with patented booster holder has been developed, which can be combined with the detonator in a simple plug-in process. The booster holder encloses the detonator and the cable is locked so as not to exert any pull on the detonator itself. The booster charge is just as easily attached to the holder using the plug-in method. The booster holder and charge have the same pressure and temperature ratings as the HTD150 detonator.

The detonators are programmed using the associated portable, battery-powered programmer and tester. Initiation patterns can be manually inserted, or data can be fed from an external system. The programming of each individual detonator is performed when it is contacted to the bus line which is then connected to the programming and testing device. After the detonators are connected, they are tested for successful contact with digital feedback.

Ignition is performed with the digital Igneo™ shooting panel. This has an intuitive user interface and, like the programming and testing device, it is portable and battery powered. The panel allows ignition of up to 1000 detonators simultaneously or sequentially and is compatible with commercially available triggers, whether wired or radio controlled.

After nearly three years of successful and intensive collaboration between DynaEnergetics and Newcrest Mining, the first field test was conducted at the Lihir Gold Mine in early 2020. The experience and knowledge gained during this field test has been incorporated into the further development of the Igneo™ system and enabled the commercial launch of the product line at a later date. The application of the Igneo™ system is thus not limited to the Lihir gold mine, but is also available for other mining projects, either in an open pit or underground environment, that are carried out under similarly extreme conditions.

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UPCOMING EVENTS

1.EFEE 11th World Conference on Blasting and Explosives, Maastricht, Netherlands, 15 till 17 May 2022

2.International Explosives Conference, London, UK – 22 till 24 June 2022

3.ANNA Conference, Houston, USA-2 till 7 October 2022

4.ISEE 49th Annual Conference on Explosives and Blasting Technique, San Antonio, USA, 3 till 8 February 2023

5.SAFEX Conference XX, Salzburg Austria, 23 till 28 April 2023

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ARTICLES FOR NEWSLETTER

This is a reminder that through the Newsletters we share knowledge in the areas of Safety, Health, Environment and Security pertaining to the Explosives Industry. SAFEX thus call on all members to submit articles on these subjects within their own companies and countries.

The deadline for articles for the October 2022 Newsletter is 30 September 2022 .I look forward to your continued support .